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The Consumption Behaviour of Peasant Households: A Case Study of Punjab, India

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ABSTRACT

This study attempts to estimate peasant household consumption functions for five subsistence crops. Two sets of factors--"real and "market" are examined. Real factors include the production of the subsistence crop and its near consumption substitute and the size of the household, while market factors include the harvest prices of the crop and its substitute and household cash incomes. The availability of time series and cross-section data provide a panel of household observations. Pooled data are used to first estimate individual household functions to obtain estimates for the first order serial coefficients, which are used to transform the data. Permitting interdependence within household crop functions and assuming away contemporaneous correlation between different households, a multivariate regression model akin to Zellner's (1962) seemingly unrelated regression equations is fitted to the pooled household data. Results indicate that "real" factors are crucial in determining the consumption behavior in the case of "subsistence" crops but that "market" factors are more important in the case of "cash" crops. The results extend Raj Krishna's analysis (1965) and suggest that until a larger proportion of their output is marketed, we can expect the price and income elasticities of demand for their own output to be insignificant for peasant households where demand is more closely dependent upon production and the size of the household.

THE CONSUMPTION BEHAVIOUR OF PEASANT HOUSEHOLDS: A CASE STUDY OF PUNJAB, INDIA *

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1. INTRODUCTION

The purpose of this paper is to present some results of an investigation into the consumption behaviour of peasant households with respect to their own outputs. The motivations for this study were provided by a larger investigation of the problems of supply response in a less developed country.[1] In the course of that investigation it became apparent that it was not possible to study the behaviour of the supply of agricultural output without at the same time studying the consumption behaviour of peasant households with regard to outputs produced on their own farms. An attempt was made therefore to predict the peasant households consumption of several farm produced outputs and to view these predicted consumption levels as constraints on the production possibilities faced by a peasant farmer. This paper reports the results of this part of the larger study for the state of Punjab in northwest India.

The remainder of this section discusses the nature of subsistence production and its implications for the study of consumption behaviour as an integral part of the study of supply response in underdeveloped agriculture, and gives some data on the extent of one element of this subsistance in the Punjab. The second section presents a discussion of the determinants of consumption of farm produced outputs in a peasant household and the data sources available for the Punjab. Due to data difficulties the third section is devoted to developing a statistical model and estimation procedures which

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1 The purpose of this study was to isolate the factors responsible for the substantial growth in Punjab and to relate them to policy parameters at a regional level. See SINGH (1968).

allow us to make the best effective use of the available data. Problems of serial correlation, contemporaneous correlation and aggregation bias are the result and the approach developed uses cross-section time and series data in a multivariate regression model. Section four discusses the empirical results and the last section draws some tentative conclusions.

1.1 The Nature of Subsistence

The farm combines two fundamental units of microeconomic analysis - the household and the firm. Some attention has been given to the resulting firm-household interdependence in the economic analysis of agricultural production by HEADY (1953), DAY (1962) and DAY and HEIDHUES (1967), but their main focus of attention has been developed agriculture. While this interdependence is clearly of the essence in the analysis of traditional (peasant) agriculture, scant attention has been paid to its implications for economic analysis. The exceptions have been NAKAJIMA (1957, 1958, 1963 and 1964) and MELLOR (1965, 1966), who have tried to give a theoretical framework to this interdependence, but their insights have yet to be incorporated into any empirical model of production response in the LDCs. One of the implications - the importance of the study of the consumption of retained outputs in the broader study of supply response - is best understood in the context of the notion of subsistence production.

NAKAJIMA (1965) points out that a subsistence production family farm has two characteristics: i) a high proportion of the production on the farm is consumed by the farming household which depends upon the farm to provide to a large extent its production needs, especially for food, and

ii) there is a large proportion of family labour in the total labour input on the farm which depends upon the household for this major input. As a result it becomes impossible to differentiate the decisions to produce from the decisions to consume, since by its very nature the returns to a family farm are indifferentiable. One of the most explicit implications for the study of supply response is that we can expect decisions to consume (especially to consume farm outputs) to modify the decisions to produce. This is so for several reasons:

i) Consumption and Cropping Patterns

Since a peasant household depends to a large extent on the farm for its consumption requirements, especially for food crops, it is evident that to the extent that a firm is required to produce these outputs it is unable to devote the land so used to the production of other crops that might be more profitable. Thus consumption needs modify response to price and profitability and retained consumption can be viewed as a constraint on the production decisions. This is the main barrier to specialization and commercialization of peasant agriculture even where markets and transportation exists. It is quite possible in the latter case for some individual farmers to produce totally for the market, selling all their outputs and receiving cash incomes to allow them to purchase their consumption needs, but for the region as a whole this is impossible - given the assumption that we are concerned with a region that has a high proportion of subsistence farmers. The dependence on farm outputs for consumption maybe due to many reasons, among which a non-monetized economy, lack of transportation and communications, imperfections of markets and the integrated nature of the village economy come readily to mind. Whatever the reason, in a region characterized by subsistence production, production alternatives and cropping patterns are constrained by the needs of domestic consumption.

ii) Consumption and the Marketable Surplus

Not only is the choice of cropping patterns constrained (in a given region characterized by subsistence production), but consumption also affects the volume and composition of the marketable surplus. Both the volume and the composition of this surplus can be viewed as the outcome of two mutually interdependent decisions - the decision to produce and the decision to retain the outputs for home consumption - and not merely the arithmetic difference between the quantity produced and the quantity consumed. This view of the marketable surplus would suggest that attempts to estimate its elasticity in response only to prices or short run profitability would fail to account for both aspects of the problem. It is reasonable to suggest that the decision to produce is in response to one sets of factors (expected input and output prices, expected yields and transportation costs), while the decision to consume is in response to another set (family incomes, family size and actual output of the crop). If this is really the case then the two decisions have to be analyzed in response to the appropriate set of factors and then integrated into a single decision model.

iii) Consumption and Cash Flows

The most explicit impact of consumption decisions on production is through the cash flows generated in a peasant household through the sale of the surplus. The total volume and composition of the surplus determine the total volume of cash incomes available to the peasant household. This cash along with relatively small amounts of "non-farm" cash incomes and the net increase in his debts (excess of available credit over his repayment obligations) is the total "working capital" that a peasant household has for a) the purchase of cash inputs for the next production period; b) the purchase of consumer goods not produced on the farm and c) the purchase of fixed and quasi-fixed inputs to augment his production base and make it more productive. Thus consumption decisions impinge upon production, credit, investment and even technological change. The importance of cash flows for investment and technological change become evident when one considers that many of the new inputs in agriculture (water, seeds and feterilizers) are "cash intensive" inputs. Thus the greater the proportion of total output retained for consumption, the smaller the volume of internally generated cash flows and the smaller the ability of the peasant farmer to transform his production techniques.

In view of what has been said above it become evident that an attempt has to be made to predict as accurately as possible the amounts of various farm produced goods that are retained behind for household consumption, and the factors that affect them. This paper is an attempt in this direction.

1.2 The Extent of Subsistence in the Punjab

Keeping in mind our main concern with one aspect of the problem of subsistence production - the percentage of total output of a crop retained for consumption by the peasant household - and defining subsistence to be this percentage, the extent of subsistence in the Punjab varies according to the crop under consideration.

Table 1 gives the value of different food items furnished by the farm as a percentage of the total value of the item consumed from 1954-55 to 1964-65.[2] As is evident from the table the extent of subsistence has been high for all foodgrains--wheat (90%), Maize (87%), Rice (70%), and Pulses (53%)--and for milk and milk products (95%). It can also be seen that the level of subsistence has not varied too greatly over the period in these crops.

Sugar is an exception. It's level of subsistence is small and varies widely from year to year. The reason for this is that the amount of sugarcane processed into brown sugar on the farm depends upon many factors - the market price of sugarcane, the market price of brown sugar (which is sold in the village), the cost of processing sugarcane into brown sugar and the availability and price of refined sugar. Since brown sugar and refined sugar are very close substitutes, an increase in the price of sugarcane relative to the price of brown sugar and refined sugar usually results in farmers selling sugarcane and purchasing refined sugar if its available. Alternatively, a drop in the price of sugarcane relative to the price of brown sugar (or its cost of production) and the price of refined sugar

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2 The data is from a smaple of between 18-26 cultivating families in Punjab and Haryana, the size of the sample varying according to the year in which the survey was conducted.

results in the processing of sugarcane on the farm and the consumption of brown sugar. This accounts for the wide variation in the level of subsistence for sugarcane. These facts also suggest that even when the level of subsistence is small production decisions are not independent of c nsumption considerations.

The main focus of the study of subsistence in the Punjab are the five food crops - what, maize, rice, sugarcane and pulses. In 1964-65 these subsistence crops accounted for approximately 70-75% of the total food expenditures in peasant households, for 72% of the value of farm output and for 63.3% of the gross area cultivated. Since we can estimate the percentage of total income from cultivation to be about 70% we can say that these crops account for roughly 50% of total household incomes in the Punjab.[3] Therefore we are concerned with a major proportion of both the production and consumption aspects when we consider these crops.

The most important of these crops is wheat, which in the Punjab constitutes the major part of the diet. Maize is a very close substitute for wheat in the diet, while rice is relatively less so, even though from a nutritional point of view rice is a very good substitute. Sugarcane processed into brown sugar is the main source of carbohydrates along with the main food grains, while pulses are common protein sources and can also be considered as inferior food grains. Since wheat and most of the pulses are winter (rabi) crops they do not compete directly for land resources with the other three crops which are summer (kharif) crops. However they

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[3] The data on gross area cultivated is for the five central Punjab districts, whereas the other data is from the farm budgets. See Statistical Abstract of the Punjab 1964.

TABLE 1

The Value of Different Articles of Food Furnished by the Farm as a Percentage of the Total Value Consumed, Punjab, 1954-55 to 1964-65

ITEM	'54-'55	'55-'56	'56-'57	'57-'58	'58-'59	'59-'60	'60-'61	'61-'62	'62-'63	'63-'64	'64-'65	Aver.
Wheat	87	89	94	88	87	92	94	91	93	88	91	90.4
Maize[1]	88	84	92	88	77	84	92	92	92	83	85	87.0
Pulses[2]	56	55	51	54	63	60	46	57	47	54	45	53.5
Sugar	50	40	34	33	32	37	35	24	13	52	41	39.1
Rice	66	70	74	68	64	84	72	78	73	67	60	70.5
Milk and Milk Products	98	96	95	95	95	95	95	95	96	94	95	95.4

[1] Includes maize and other minor cereals.

[3] Farm processed brown sugar.

[2] Gram is the major pulse included.

<u>Source</u>: <u>Family Budgets of —— Cultivators in the Punjab, 1954-55,......, 1964-65</u>, The Board of Economic Inquiry, Punjab, India, The Economic and Statistical Organization Government, Punjab. Publication nos: 44, 52, 57, 59, 73, 82, 85, 94, 101, 105 and 114.

do compete for all other inputs that do not have a seasonal nature. They all compete in the total consumption budget of the peasant household.

Other important crops grown by peasant farmers in the Punjab for the purpose of retaining their output are fodder crops. These alone account for between 15-20% of the gross area cultivated, and are grown mainly to feed the livestock that provides both the motive power on the farms as well as milk products. These crops are not considered here because the factors that determine their demand are different - the fodder requirements being determined by the number of draught and milch animals and their nutritional requirements in relation to such factors as work load, temperature and moisture and time of the year.[4]

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4 For some estimates of fodder requirements per animal in the Punjab see SINGH, I. J., DAY, R. H. and JOHL, S. S. (1968), pp. 97-100.

2. THE DETERMINANTS OF CONSUMPTION

Our main concern is with the factors that effect the level of consumption of foodgrains in a peasant household. Though there have been some attempts to estimate the marketable surplus function of subsistence crops,[1] no attempts have been made to estimate the consumption function for a subsistence crop. In general six factors effect the level of consumption of a subsistence crop in a peasant household. These can be considered in two groups - a set of "real" factors and a set of "monetary" factors.[2] The real factors are 1) the total current output of the crop, 2) the size of the peasant household and 3) the total current output of a crop that is the nearest consumption substitute. The monetary factors are 4) the level of household incomes, 5) the current price of the crop and 6) the current price of a near substitute crop. The relative importance of the real factors reflect to a large extent the degree of the monetization of the rural economy and the decision processes in it, and thus reflect the extent to which conventional economic factors like income and prices (or in general market forces) play a role in the decisions to consume in a peasant household.

2.1 Current Output

The relationship between the consumption of the m^{th} crop subsistence crop ($C_{jt,m}$) and its current output ($Q_{jt,m}$) for the j^{th} household in the

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1 See Raj Krishna's pioneering study for India (1965 and comments on it by C. H. Rao (1965), N. Krishnaji (1965), M. Majumdar (1965) and B. Prasad (1965) and Behrman (1966).

2 The distinction is not too valid but is used for purposes of clarification.

ear can be viewed in four stages as illustrated in figure 1.

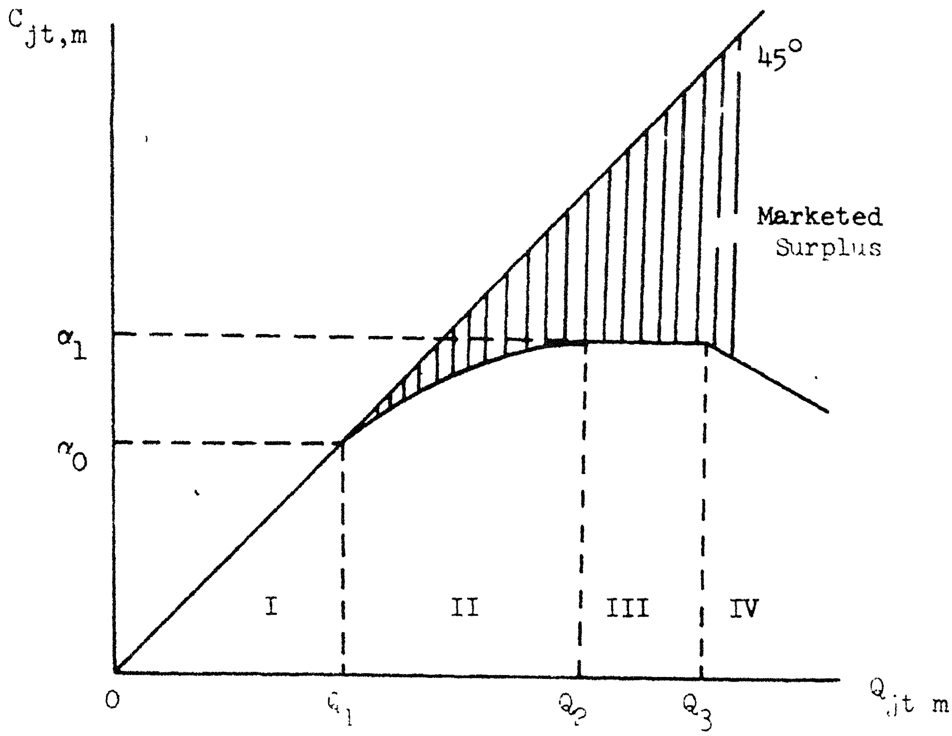

Figure 1 Relationship Between Consumption and Output of a Subsistence Crop

In Stage I all the output is consumed so that the function lies on the 45° line. This is likely to be the case when the level of consumption is at or below "subsistence levels of consumption". Such a subsistence level though ambiguous and difficult to define[3] is directly related to nutritional

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[3] See Clark and Haswell (1964), F.A.O. (1950, 1957) and Wharton (1958).

standards.[4] It can be expected that until this level α_o is reached all output will be absorbed by consumption, so that the marginal propensity to consume out of output is unity in this stage.

In Stage II the mpc is less than one but greater than zero and increases in consumption contribute to improved nutritional standards. Since mpc is less than one, marketable surplus is positive and if sold contributes to cash incomes. The level α_1 can be considered as a "sufficing level of consumption" where the household satisfied with its consumption of the foodgrain in question enters Stage III[5]. In Stage III the mpc with respect to output is very close to zero and all additional output is available as marketable surplus. In the last stage further increases in output actually lead to a decline in consumption due to a substitution of other food items in the diet, specially if the crop is considered nutritonally inferior. Thus in Stage IV the mpc is negative. Over the entire range of output a non-linear relationship between output and consumption is suggested.

There is some evidence that most peasant cultivating households in the Punjab are in Stages II and III. According to F.A.O. nutritional studies (1950) the average calorie requirement per day for an adult weighing 55 kg. under 25.5^{o} centigrade of temperature (which closely approximates

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4 This assumes that the consumption mix of different foodgrains in the diet does not vary greatly. It is difficult to define subsistence levels of a single output in the case of a household-firm producing more than one crop.

5 The level of α_1 maybe very close to α_o in the case where α_o is defined such that a minimum diet includes enough nutrition to carry out farm activities. See F.A.O. (1957)

the mean annual temperature in the Punjab) is 2040. If we assume that nothing but cereals are consumed this calorie level can be obtained from about 20 oz. of cereals.[6] Nutritional surveys of rural households conducted by the Indian Council of Medical Research (1950-1961) show that the daily caloric intake of the Punjab ranges from 3027 calories to 3573 calories (Report, 1960, p. 4), while the daily intake of cereals in 20.1 oz. on the average (Reports 1954, p. 54 and 1961, p. 36). This suggests that at least from a nutritional point of view the Punjabi farmer is above subsistence. It is still possible for him to be in Stage I if he consumes all marginal increments in output. There is some evidence, however, that the marginal propensity to consume is less than one, so that marketable surplus is being generated by an average farming household in the Punjab. In regressing marketable surplus against output for Punjab cultivating households Raj Krishua found that "the best predictor for marketable surplus was the output of the subsistence crop itself" (1965, p. 315) and the very high R^2 between marketed surplus and output obtained in his study in the case of wheat (.89 to .98) suggests that there is no proportional relationship between consumption and output, at least in the case of wheat.[7] Therefore in general we may expect $0 \leq \partial C/\partial Q < 1$, where C is retained consumption

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6 Assuming a conversion factor of 360 calories per 100 gms. of cereals. See F.A.O. (1950)

7 Since C + M = Q where C is consumption and M is marketed surplus and Q is output, and if 89 to 96 percent of the variation in Q is explained by M. C must be stable and fairly constant over a range of Q, as argued by Krishna. This is one example where surplus is considered as an arithmetic difference.

and Q is output.

2.2 Family Size

The most important determinant of the domestic consumption of a subsistence crop is the size of the peasant household. It is to be expected that as the size of the family increases its consumption needs also increase so that the m.p.c. with respect to family size is positive. However a measure of the size of family that accounts for only the number of persons in a household in inadequate from the point of view of measuring the demand for food. In a peasant household food intake is also partly related to work loads and therefore a measure is need that accounts for both the age and see distribution in the household. A measure of the family size that attempts to do this is Atwaters Index which measures the family size in adult male unit equivalents by assigning a different weight by age group and sex.[8] The sum of this weighted index is a better measure of the concept of family size and its relation to consumption.

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[8] Atwater's Index assigns the following weights:

Age	Equivalent Adult Male Units	
	Male	Female
Over 16	1.0	0.8
15-16	0.9	0.8
13-14	0.8	0.7
12	0.7	0.6
10-11	0.6	0.6
6- 9	0.5	0.5
2- 5	0.4	0.4
Under 2	0.3	0.3

See B. E. I. (1964-65, p. 4)

2.3 Output of the Substitute Crop

In the case of cereals that are close substitutes for one another in the household diet - wheat, grain, maize and rice - one would expect that a family would be free to substitute one crop for another at all levels of income. Such a substitution is all the more probable when different crops are grown in a different season. Thus for example a poor yield of rabi crops (wheat and grain) might lead to an increased consumption of kharif crops (maize and rice) to make up for the loss in the diet. Even with crops grown in the same season the amount of a crop retained for consumption depends to some extent on the amount of a substitute crop available. Thus we would expect that the consumption of a substitute crop is likely to decline with an increase in the output of a close substitute.

2.4 Household Income

In considering the effect of output of a subsistence crop on consumption we have been concerned with one of the components of household income. Here we are concerned with the combined effect of total income of the j^{th} household (Y_{jt}) on its consumption of the m^{th} subsistence crop ($C_{jt,m}$) in t. The relationship between the two shown in Figure 2 can be viewed in three stages.

In Stage I the marginal propensity to consume out of income is between zero and one. Then as income increases beyond Y_1 the relationship becomes nearly asymptotic to β_1 suggesting a m.p.c. with respect to income close to zero. It is possible that beyond a certain income Y_2

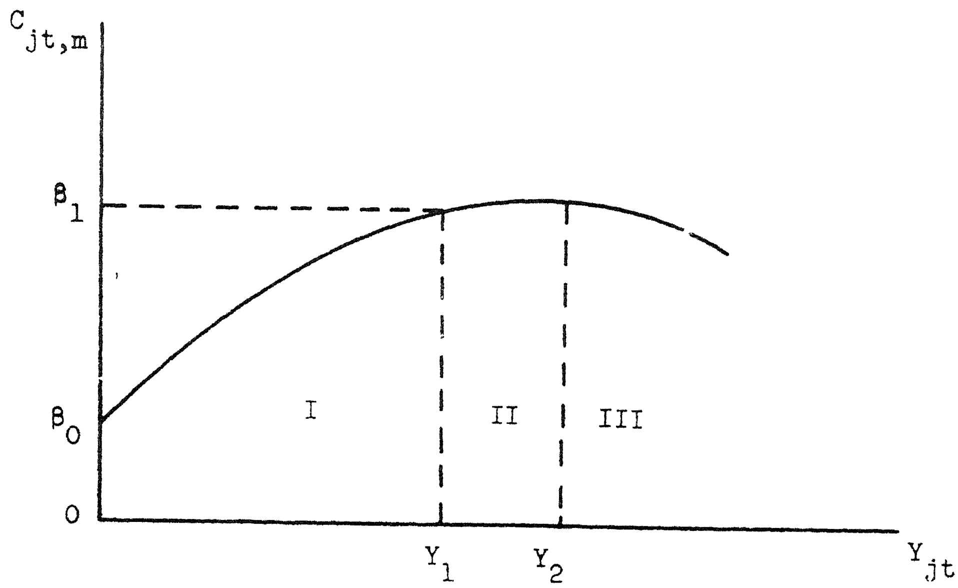

Figure 2 - Relationship between total household income and the consumption of a subsistence crop.

the m.p.c. becomes negative as the subsistence crop is viewed as an inferior good in the diet and its consumption begins to fall in Stage III.

In the Punjab it is possible that inferior foodgrains such as pueres and maize may be replaced in the diet by wheat and rice, which in turn are replaced in the diet by increasing amounts of fruit and meat products. There is some evidence that in the case of both foodgrains and cereals their consumption is related to income in a non-linear manner. Monthly per capita foodgrain and cereal expenditures are plotted against total monthly per capita expenditures for various expenditure classes in Figure 3 [9]

[9] The data is from the National Sample Survey, 13th Round September 1957-May 1958, and the 14th Round 1958-May 1959. See (NSS. p. 78-79) and (NNS. p. 86-87).

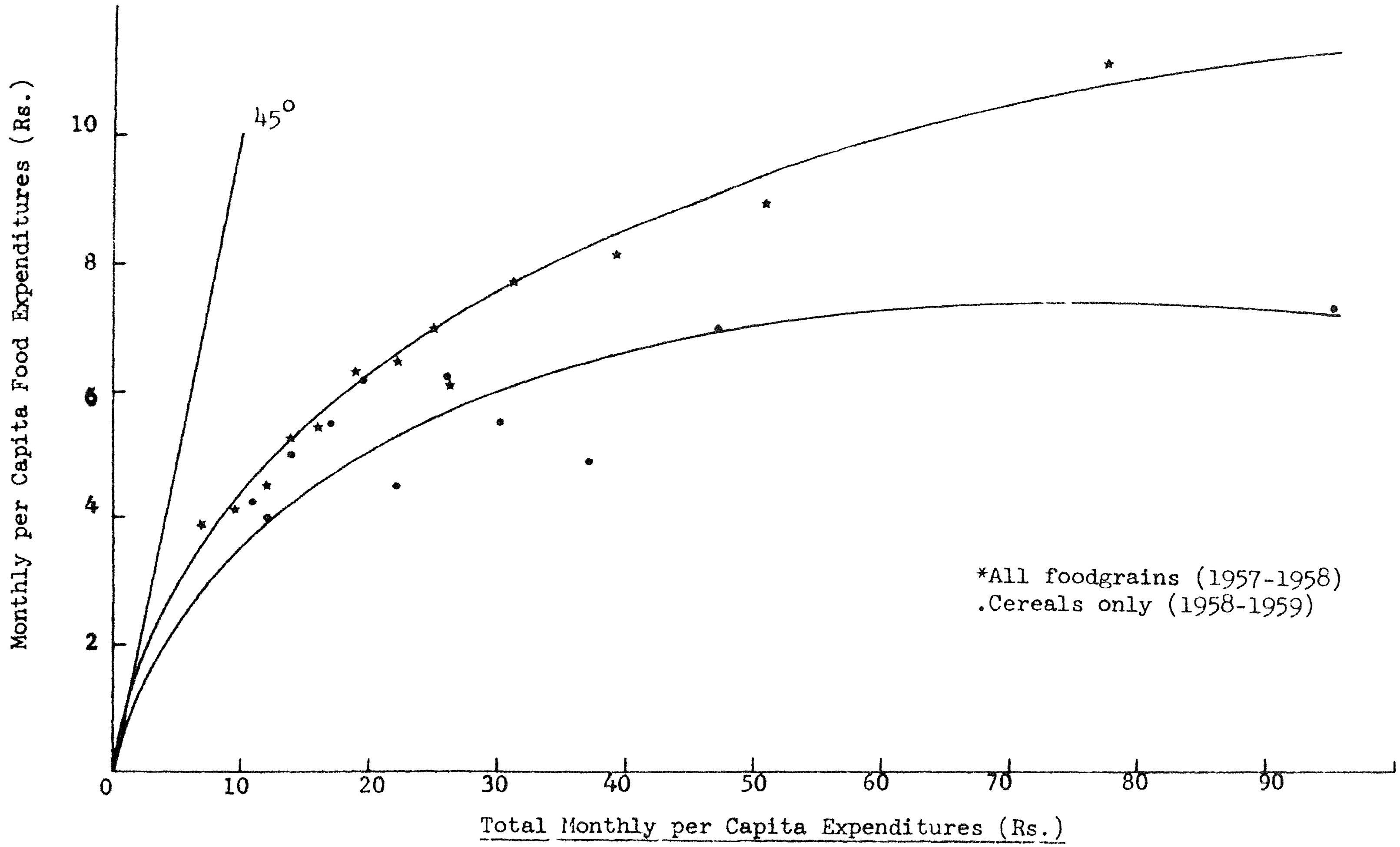

Figure 3 - Monthly per capita total and foodgrain expenditures
Punjab Rural Households, 1957-58

and curves fitted by hand support this contention cuirsorily.

As shown earlier there is a relationship between the total output of food crops and total income. If we assume that a farmer grows only one crop and all his income is derived from the sale of this crop alone then

$$Y = p \cdot Q$$

where Y is total income, p is the unit price of the output and Q is total output. When k crops are grown then

$$Y = \sum_k p_k Q_k + R$$

where R is income from sources other than cultivation.

More generally the consumption of one crop can be viewed as a function of the prices and outputs of all crops as follows

$$C_k = f_k(P_1 \ldots P_k, Q_1 \ldots Q_k)$$

Since the price and output of the subsistence crop and its nearest substitute are included explicitly the total income variable then reflects the contribution to income of the value of outputs not included as well as income from sources other than cultivation. For any given subsistence crop the correlation between its output and total household income is low, therefore the latter is included explicitly.

2.5 Price of the Subsistence Crop

To the extent that subsistence needs have been satisfied the effect of an increase in the market price of a subsistence crop is to decrease its consumption. We would therefore expect the price response to be negative. However there are cogent arguments in favor of a positive response of consumption to price in peasant consumer behaviour. A positive price response is possible in two cases:

Firstly, if the subsistence crop in question also constitutes a substantial amount of the total real income of the farming household (or cash incomes if it is also sold), an increase in its price would also imply an increase in real income and the income effect would be large enough to offset any negative price effects.[10] Secondly, if the subsistence crop constitutes a substantial part of the diet (a large proportion of the family budget in real terms) and if there is an expectation of substantial price increases during the year, the opportunity cost of selling and then buying back for consumption is so large that price increases actually increase retained consumption to the extent that it is below the sufficing level α_1. It is not possible therefore to know a priori what the value of $\partial C_j/\partial P_j$ would be where P_j is the current price of the j^{th} subsistence crop.

This brings out an interesting point in regard to the literature on the price responsiveness of peasant producers. Keeping in mind the earlier arguments of marketable surplus it is evident that the elasticity of the marketable surplus to price is the result of two separate elasticities - the elasticity of output to price and the elasticity of consumption to

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10 In conventional consumer theory a fall in the price of a good is considered as involving a positive income effect, but in the case of a consumer who is also a producer of the good in question it is a rise in price that constitutes a positive income effect.

price[11]. In general one expects the former to be positive and the latter to be negative so that their sum is usually positive. However in cases where the consumption increases with an increase in price, the elasticity of the marketable surplus to price may very well be very small even though the price responsiveness of output is large. In such case it is often wrongly inferred that peasant producers do not respond to economic incentives when only the response of marketable surplus to prices is being examined. This has led to broad and often wrong generalizations about the effectiveness of market incentives in transforming traditional agriculture.

2.6 Price of the Substitute Crop

The argument for including the price of the substitute crop are the same as for including the price of the subsistence crop. In general however we would expect that as the price of a close substitute increases it would increase the consumption of the subsistence crop. This increase is greater, the greater is the elasticity of substitution in the diet of the household between the two crops. However again due to the existence of possible income effects it is not possible to say a-priori what the sign of this price response will be.

2.7 The Data

There are two sources of data on consumer expenditures in the Punjab:

(1) National Sample Surveys (Government of India)

(2) Board of Economic Inquiry (Punjab)

Though some of the data from the National Sample Surveys conducted by the Government of India are available, it was rejected for the purpose

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[11] If $Q - C = M$, then $(\partial Q/\partial P) - (\partial C/\partial P) = \partial M/\partial P$.

at hand - the estimation of consumption functions for estimating the amount of the output retained for consumption - for the following reasons:

(1) The data is in expenditure terms only where imputed values have been given to items of retained consumption.

(2) The data does not give detailed information on the consumption of various foodgrains, lumping most of them under 'cereals' so that it is not possible to arrive at separate estimates for the various crops.

(3) Only average values for household incomes and expenditures in given expenditure classes are available since the raw data is not available in published form.

(4) The data covers a sample of all rural households while our concern is mainly with the consumption of farm family households.

(5) The surveys have been conducted intermittently so that it is difficult to get an idea of the patterns of consumption over the time period that the model covers.

(6) There is no comparable production data available.

In contrast to this the Board of Economic Inquiry data is available in terms of physical units of consumption and avoids the problem of imputed values gives a detalied breakdown of crops of consumption, covers only cultivating households, is avaiable for a continuous period of over a decade and a half, from 1950-51 to 1964-65 and even earlier and is supplemented by production data. The data suffers from two drawbacks in that it is collected from selected households and is likely to have some bias and its quality is relatively poor compared to the NSS data.

In view of the fact that there is no comparable data which gives us both the household's consumption and production of subsistence crops to allow us to test our theories, the Board of Economic Inquiry (B.E.I.) data was used.

The data for household consumption of wheat, maize, rice, sugar and pulses, household incomes and household size in terms of Adult male equivalents is taken from the Family Budgets for cultivators in the Punjab (BEI) and this is supplemented by data on outputs for the same cultivating households from the Farm Accounts (BEI) in the Punjab over the same period. The data on prices is taken from the Statistical Abstracts of the Punjab while data for the consumer price index deflator is taken from the Index Number of Parity Between Prices Received and Paid by Farmers in the Punjab (BEI) over the same period.

From a varying set of households for which data is available it was possible to get only 9 households for which data could be traced over a period of 11 years (1954-55 to 1964-65 both inclusive).[12] This gave a panel of 99 observations (9 households for 11 years each) for the purpose of analysis. Due to the small size of the cross-section (only a households) as well as the small size of the time series (only 11 years) this presented severe problems from the point of view of the estimation of parameters of any model that would include all the determinants discussed above. In view of this and because data was available on the same households over some period a statistical model had to be developed to allow us to take advantage of pooled data. A description of this model follows.

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[12] This was due to the turnover of households in the surveys.

3. STATISTICAL MODEL AND ESTIMATION PROCEDURES[12]

Since there are only 9 households on which data is available an attempt is made here to combine the cross-section data with the time series data on each household into a panel. It has been shown that panel data of this sort allows a substantial analytical advantage to be gained from having both time series and cross-sections for an identical group of observations. Kuh [1957, 1959] However since there are many problems in the analysis of such data, the statistical arguments will be developed step by step for simplification of the estimation procedures.

3.1. Serial Correlation

To begin with consider the behavior of an individual household through time where according to our earlier formulation we could write the relationship between consumption and its determinants as follows:

$$C_{jt,m} = f_{jm}(x^1_{jt}, \ldots, x^k_{jt}) \tag{1}$$

$$m = 1, \ldots M$$

$$j = 1, \ldots N$$

$$t = 1, \ldots T$$

where $C_{jt,u}$ is the consumption of j^{th} household in year t of the mth subsistence crop, f_{jm} are functions relating the consumption of the j^{th} household for the m^{th} crop to $x^1_{jt}, \ldots, x^k_{jt}$ a set of k independent variables for the j^{th} household in year t.

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[12] I am indebted to Professor Dennis Aigner for his help in understanding the many intricacies of the econometric estimation procedures. Without his help this section would not have been possible. Several errors that remain are mine.

However, in the use of time series data to estimate these functions (jxm of them) it has been shown that due to serial correlation ordinary least squares estimates would be biased. Cochrane and Orcutt [1949]. To take account of the possibility of serial correlation consider the following model:

$$C_{jt} = \beta_o + \beta_1 x^1_{jt} + \ldots + \beta_k x^k_{jt} + u_t \ldots \qquad (2)$$

$$t - 1, \ldots T$$

where we are considering only the j^{th} household and only one crop, and where C_{jt} and x^k_{jt} are as defined above and β_o, β_1, ..., β_k are the regression coefficients and u_t is the error term. If we assume that the disturbance term u_t follows a first order autoregressive scheme

$$u_t = \rho u_{t-1} + e_t \qquad (3)$$

where $\left|\rho\right| < 1$ and e_t satisfies the assumption

$$E(e_t) = 0$$

$$E(e_t e_{t+s}) = \sigma^2_\epsilon \qquad s = 0$$

$$= 0 \qquad s \neq 0 \quad \text{for all } t$$

then it can be shown that

$$E(u) = 0$$

$$E(u_t u_{t-s}) = \rho^s \sigma^2_u \qquad s \neq 0$$

$$= \sigma^2_u \qquad s = 0 \quad \text{for all } t$$

and the covariance matrix is

$$(4) \qquad \lambda = \sigma_u^2 \begin{bmatrix} 1 & \cdots & \cdots & \rho T\text{-}1 \\ \rho & 1 & & \vdots \\ \vdots & & \ddots & \vdots \\ \rho T\text{-}1 & \cdots & \cdots & 1 \end{bmatrix}$$

In order to take account of this serial correlation the following procedure has been suggested: Goldberger [1963], Johnston [1960].

1) For each individual j^{th} household use the time series data to run an ordinary least squares regression

$$C_t = \beta_o + {}_i\beta_i x_t^i + u_t \; .$$

2) From the computed residuals $\hat{u}$ of the first step get an estimate $\hat{\rho}$ for ρ as follows

$$\frac{\sum_{t=2}^{T} \hat{u}_t \, \hat{u}_{t-1}}{\sum_{t=2}^{T} \hat{u}_{t-1}^2}$$

which is an estimator of the coefficient of the first order autoregressive scheme.

Since there are j households and μ crop functions under consideration the $\hat{\rho}$ has a j and μ subscript identifying the household and the crop under consideration.

3) The coefficient $\hat{\rho}_{j\mu}$ is then used to compute transformed variables for each household and each crop such that

$$(C_{jt,u} - \hat{\rho}_{j\mu} C_{jt-1,\mu}) = C^{*}_{jt,\mu}$$

and

(6) $$(x^{k}_{jt,\mu} - \hat{\rho}_{j\mu}\, x^{k}_{jt-1,\mu}) = x^{k*}_{jt,\mu}$$

$$\text{for } t = 2, \dots T$$
$$j = 1, \dots n$$
$$\mu = 1, \dots m$$
$$k = 1, \dots k$$

It is then possible to rewrite (1) in terms of the transformed variables as follows:

(7) $$C^{*}_{jt,\mu} = f_{ju}(x^{1*}_{jt}, \dots, x^{k*}_{jt})$$

More explicitly for each j^{th} household for which T time series observations were available, the following function was estimated for each of the crops under consideration - wheat, maize, rice, sugarcane and pulses:[13]

(8) $$C_{jt} = \alpha_o + \alpha_1 A_{jt} + \alpha_2 Y_{jt} + \alpha_3 Q_{jt} + \alpha_4 P_t + \alpha_5 S_{jt} + \alpha_6 P_{sjt} + \alpha_7 Q^2_{jt} + \alpha_8 Y^2_{jt} + u_{jt}$$

$$t = 1, \dots T$$

where for the μ^{th} crop

C_{jt} = Annual consumption of the subsistence crop of the j^{th} household in year t (In Kilograms).

A_{jt} = Size of the j^{th} household in year t. (Measured in Adult male equivalents.)

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[13]A log form of the equation was not possible because in many cases $C_{jt} = 0$ and Q_{jt} and $S_{jt} = 0$ - that is for some households there was either no production or no consumption of specific crops. So the quadratic form was tried.

Q_{jt} = Total output of the subsistence crop on the farm cultivated by the j^{th} household in year t. (In Quintals).

Y_{jt} = y_{jt}/I_t^P where y_{jt} is the total household income in year t and I_t^P is is a price index deflator for year t*. Thus Y_{jt} is the deflated household income. (In Rupees).

P_t p_t/I_t^P where p_t is the harvest price of the subsistence crop and I_t^P is a price index deflator for year t.[14] Thus P_t is the deflated price of the subsistence crop. (In Rupees per quintal).

S_{jt} = Total output of the substitute crop on the farm cultivated by the j^{th} household in year t. (In Quintals).[15]

P_{st} = p_{st}/I_t^P where p_{st} is the harvest price of the substitute crop and I_t^P is a price index deflator for year t. Thus P_{st} is the deflated price of the substitute crop. (In Rupees per Quintal).

and Q_{jt}^2 and Y_{jt}^2 are the squared terms of Q_{jt} and Y_{jt} respectively to allow for the non-linearity in the relationship between consumption and these two variables as suggested by our hypotheses in Section 2. (The data was for the years 1954-55 to 1964-65 giving us T = 11.)

The coefficients of serial correlation $\hat{\rho}_{j\mu}$ for each household and each crop were estimated and are given in Table 2. From this table it can

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[14]The price index delfator used to account for the inflationary effects over the time period is the consumer index number of prices paid by farmers for food items of consumption. See [BEI].

[15] The substitute crops used are maize for wheat and rice, and wheat for maize, sugarcane and pulses.

Table 2

Estimated Coefficients of Serial Correlation for Different Households And Different Subsistence Crop Consumption Functions (1954-55 to 1964-65)

Household[a]	Obs. No.	Value of $\hat{\rho}$ for Different Crops				
		Wheat	Maize	Rice	Sugarcane[c]	Pulses[b]
Virk	01	-0.1706	-0.1028	-0.2281	-0.5273	-0.5381
Majari	02	-0.2001	-0.3369	-0.4640	+0.2024	-0.1981
Barwala	03	-0.3511	+0.2225	-0.3900	-0.3882	-0.2512
Sarinh	04	-0.2172	-0.3523	-0.3500	-0.4630	-0.3593
Rattian	05	-0.1049	-0.2949	-0.4873	-0.3796	-0.3152
Phulkhurd	06	-0.2885	-0.5014	-0.4873	-0.3796	-0.3152
Bara Gudah	07	-0.3882	-0.3059	-0.0286	-0.5783	-0.4384
Prem Nagar	08	-0.6200	-0.4528	-0.3612	-0.4179	-0.3527
Ban	09	-0.0153	-0.2024	-0.1888	-0.0486	+0.4812

[a]These are the names of the villages from which the household data is taken. For details, see Family Budgets, 1950-51 to 1964-65, B.E.I., Punjab.

[b]Data was available on the consumption of all pulses, but not their total output. So the output of grain was used, since this accounts for the major portion of all pulses under consideration.

[c]The consumption, production, and prices are for gur.

be seen that the serial correlation for some households and some crop models was indeed high. So the transformed data is used for the next step with 10 observations (T-1) for 9 households, in the transformed variables.

3.2. Contemporaneous Correlation and Aggregation Bias

Now taking the transformed data for each household and considering the possibility of pooling the data for the various households there are two important questions to be asked:

(1) Is there any contemporaneous correlation among the different households?

(2) Would the pooling of the data lead to aggregation bias?

These two questions can be more explicitly stated by considering equation (8) in terms of the transformed variables for the N individual households for a given subsistence crop:

$$\begin{aligned} C^*_{1t} &= \beta_{10} + \sum_i \beta_{1i} x^*_{1it} + v_{1t} \\ &\vdots \\ C^*_{jt} &= \beta_{jo} + \sum_i \beta_{ji} x_{jit} + v_{jt} \\ & \qquad t = 2, \ldots T \end{aligned}$$

We can now restate the two questions in the following manner:

(a) For the system of pooled data as a whole can we assume that

$$(10) \qquad E(v_{jt} v_{j't}) = 0 \quad \text{for } j \neq j' \\ = \sigma^2_j \quad \text{for } j = j' \text{ ?}$$

If this assumption is valid then we are suggesting that no contemporaneous correlation exists between households. From the point of view of our analysis the question is whether the consumption of a particular crop (say wheat) by the j^{th} household depends upon the consumption of the same crop by the j^{th} household. It seems reasonable to assume that in fact this is not so and if any contemporaneous correlation exists it is random and insignificant and hence (10) can be said to hold true for our system of equations.

(b) For the system of pooled data as a whole is it reasonable to assume that the coefficient vectors

$$(11) \qquad \begin{bmatrix} \beta_{10} \\ \vdots \\ \beta_{1i} \end{bmatrix} = \begin{bmatrix} \beta_{j0} \\ \vdots \\ \beta_{ji} \end{bmatrix} \qquad \text{for } j = 1, \ldots N \quad ?$$

More explicitly before we can pool the data the question under consideration is whether the intercepts and the slopes of the equations are the same for all the N households. A-priori it is not possible to assume (1) unless one wishes to use a very restrictive set of assumptions about all the marginal propensities to consume being the same for all the households. Though in general this set of assumptions is very restrictive from our point of view they may not be so. Our concern is not so much with individual household effects but with the aggregative consumption behavior of all households in the region for which our sample households are representative.

In case such an assumption is unwarranted it is not possible to pool the data without an aggregation bias. Theil [1954]. Therefore it would be useful to know whether indeed such a bias exists in our sample. For this purpose the following procedure is followed for each crop model:

1) Fit the equations in (9) separately for each household.

2) Sum the residual sum of squares for all the households that is

$$RSS_N = \sum_j RSS_j \qquad j = 1, \ldots N$$

3) Pool the data and consider the model

$\underline{C}^* = \underline{X}^* \underline{\beta}^* + V$ where

$$(12) \quad \underline{C}^* = \begin{bmatrix} c^*_{11} \\ c^*_{1T} \\ c^*_{j1} \\ c^*_{jT} \end{bmatrix} \quad \underline{X}^* = \begin{bmatrix} x^{*1}_{11} & \cdots & x^{*k}_{11} \\ x^{*1}_{1T} & \cdots & x^{*k}_{1T} \\ x^{*1}_{j1} & \cdots & x^{*k}_{j1} \\ x^{*1}_{jT} & \cdots & x^{*k}_{jT} \end{bmatrix} \quad \underline{\beta}^* = \begin{bmatrix} \beta^*_o \\ \beta^*_1 \\ \cdot \\ \beta^*_k \end{bmatrix} \quad V = \begin{bmatrix} v_{11} \\ \cdot \\ v_{1T} \\ \cdot \\ v_{j1} \\ \cdot \\ v_{jT} \end{bmatrix}$$

Fit the pooled data by ordinary least squares and get its residual sum of squares RSS_p.

4) Then it is possible to test for the general linear hypothesis of coefficient vector equality by using the F statistic: Goldberger [1963].

$$(13) \qquad F = \frac{N(T-k)}{(N-1)k} \cdot \left[\frac{RSS_p - RSS_N}{RSS_N} \right]^*$$

where N is the number of households, T is the number of observations per household and k is the number of independent variables (including constant) in our regression equation (8). In our panel sample N = 9, T - 10 and k = 9 and the F statistic has 9 and 72 degrees of freedom.

The RSS_j for the equations for each household and each crop model, the RSS_N for each crop model and the RSS_p from the equation of pooled data are given in Table 3 along with the F statistic. An examination of this statistic shows that it is significant at a 1% or 2% level of significance for all crops except rice in which case it is insignificant.

A similar test was made by dropping the square terms for income and output (Y^2 and Q^2) from equation (8). The various residual sum of squares and the appropriate F statistics are given in Table 4 for this 'linear hypothesis.' The F statistic in this case has 27 and 72 degrees of freedom since k = 7, and an examination shows that the statistic is significant in all cases at a 1% or 2% level of significance except for rice where it is also significant but at a 10% level of significance.[16]

The results indicate that whether we are considering the non-linear or linear hypothesis (that is non-linear or linear in incomes and outputs), we cannot accept the hypothesis of coefficient vector equality. This suggests that for all the crop models the constants and the slopes could differ significantly from household to household. In such a case we are faced with the problem of treating each household separately and aggregating each household function on the basis of the distribution of all household outputs, incomes, and family size. TSince these distributions are not available we cannot pursue this path and reluctantly have to assume away the difficulties. By pooling our data we must be aware that aggregation bias will exist when we estimate our parameters from this pooled

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[16] This test assumes that the equation for each household has the same error variance. Though this is not appropriate the more complicated test has not been applied due to its difficulty.

Table 3

Residual Sums of Squares From Unpooled and Pooled Regressions

(Non-Linear Hypothesis)

Observation No.: (j)	RSS_j for Various Crop Models				
	Wheat	Maize	Rice	Sugarcane	Pulses
01	148,730	65	686	326	2,224
02	22,742	29,213	12,365	10,620	33
03	44,973	7,221	636	19,207	-0-
04	14,203	209	25	1,442	202
05	7,084	13,120	10	4,107	395
06	63	355	1,585	4,410	647
07	130,019	44,654	53	5,712	940
08	62,041	506	23	3,039	3,301
09	34,421	6,928	5,372	9,937	-0-
$\Sigma_j RSS_j = RSS_N$ unpooled	464,427	102,260	20,755	58,811	7,743
RSS_P (pooled)	17,991,813	3,227,563	177,657	1,736,084	401,069
F Statistic	4.72†	3.82***	0.945	3.56***	6.35†

† Significant at 1% level of significance.

*** Significant at 2% level of significance.

Table 4

Residual Sums of Squares From Unpooled and Pooled Regressions
(Linear Hypothesis)

Observation Number (j)	RSS_j for Various Crop Models				
	Wheat	Maize	Rice	Sugarcane	Pulses
01	203,400	17,170	19,400	19,760	11,290
02	64,270	69,890	12,370	14,250	26,460
03	300,200	89,320	636	22,820	3,789
04	107,100	75,960	29	46,490	1,582
05	8,354	48,370	350	10,340	750
06	26,310	33,170	1,798	28,330	811
07	160,600	154,100	54	9,267	11,440
08	102,700	118,200	88	8,387	3,880
09	62,720	17,220	10,340	16,330	5,576
$\Sigma_j RSS_j = RSS_N$ (unpooled)	1,035,654	623,400	45,065	175,974	65,578
RSS_p (pooled)	18,020,000.0	3,438,000.0	206,700.0	1,802,000.0	433,800.00
F Statistic	7.91†	2.18***	1.73*	4.46†	2.71***

27.56

†Significant at 1% level of significance.

***Significant at 2% level of significance.

*Significant at 10% level of significance.

data. Aware of the existence of such a bias, but faced with the paucity of data, we are left with no alternative but to proceed to pool the data and make the restrictive assumption that all households behave similarly in their consumption behavior. We then proceed to use the pooled data for estimating the parameters.

1.s. Structural Interdependence

So far we have been considering the possibility of pooling the data for observations on k + 1 dependent and independent variables for one crop. Now for the pooled data of (N x T-1) observations consider the following system of m simultaneous equations, one for each crop

$$(14) \qquad \begin{aligned} \underline{C}_1^* &= \underline{X}_1^* \underline{\beta}_1^* + V_1 \\ &\vdots \\ \underline{C}_m^* &= \underline{X}_m^* \beta_m^* + V_m \end{aligned}$$

where $\underline{C}^*$, X^* and V are defined as in (12) for each crop.

If we were to use ordinary least squares on the pooled data for each crop separately we would in effect be assuming that

$$(15) \qquad \begin{aligned} E(V_m V_{m'}) &= 0 \qquad m \neq m' \\ &= \sigma_m^2 \qquad m = m' \end{aligned}$$

That is to say in effect that the household's consumption of one crop (say wheat) is independent of the consumption of all other crops. Keeping in mind the fact that in the food budget of the peasant household most of the crops under consideration are very close substitutes this assumption is not in the least tenable. On the contrary for any given household in any given year we would expect the consumption of one crop to be highly dependent on the consumption of other crops, so that in fact (15) is not true. The estimation of such a system of m equations in a multivariate regression model is described by Zellner [1962] and is akin to his case of the estimation of seemingly unrelated regression equations in the reduced form. The whole system can be written as follows:

$$(16) \qquad \begin{bmatrix} \underline{C}_1^* \\ \underline{C}_2^* \\ \underline{C}_m^* \end{bmatrix} = \begin{bmatrix} \underline{X}_1^* & \cdots\cdots & 0 \\ & \underline{X}_2^* & \\ 0 & & \underline{X}_m^* \end{bmatrix} \begin{bmatrix} \beta_1 \\ \\ \bar{\beta} \end{bmatrix} + \begin{bmatrix} V_1 \\ \\ V_m \end{bmatrix}$$

where the C vector is (N x T - 1 x m), X is a block diagonal matrix of (N x T - 1 x m x mk) observations on k independent variables and the β vector is mk x 1 vector of coefficients and the v vector is a (N x T - 1 x m) vector of error terms.

Table 5 gives the estimates of the parameters for the multi-variate system in (16) for both the linear and the non-linear hypothesis along with the standard error of the estimates. The results in Table 5 can be compared with the results in Table 6 which gives the coefficients of the system in (14) where the pooled data is used to estimate the consumption function of each crop separately without taking account of the inter-crop error covariances and assuming that (15) holds true.

TABLE 5

TABLE OF COEFFICIENTS FOR CONSUMPTION FUNCTIONS OF VARIOUS CROPS
EACH CROP FUNCTION FITTED SEPARATELY (POOLED DATA)

(Linear and nonlinear hypotheses)

Crop/ Equation	Constant	Independent Variables A(t)	Y(t)	W(t)	P(t)	S(t)
Wheat						
Linear	126.71 (.373)	154.44 (7.384)[a]	0.0501 (1.313)	0.0932 (.267)	10.802 (.785)	-11.509 (2.8)
Nonlinear	85.932 (.207)	152.75 (7.018)[a]	.0856 (.728)	-.1753 (.025)	11.349 (.803)	-11.242 (2.604)[a]
Maize						
Linear	-440.58 (3.041)[a]	57.364 (6.06)[a]	-.0085 (.54)	9.1969 (4.805)	11.574 (1.745)[b]	-3.3708 (2.286)[b]
Nonlinear	-370.14 (2.54)[b]	71.782 (7.27)[a]	-.0924 (.324)[b]	10.254 (2.869)[a]	13.373 (2.041)[b]	-3.623 (2.452)[b]
Rice						
Linear	-80.977 (1.683)[c]	3.6425 (1.828)[c]	-.0007 (.182)	.9865 (3.341)[a]	1.4411 (1.152)	-.7917 (1.658)[c]
Nonlinear	-103.57 (2.273)[b]	3.206 (1.692)[c]	.0136 (1.51)	4.0103 (3.963)[a]	1.8537 (1.57)	-.6175 (1.336)
Sugarcane						
Linear	-49.82 (.499)	40.69 (6.714)[a]	.0138 (1.217)	.7057 (.61)	-5.7062 (3.404)[a]	-.962 (1.077)
Nonlinear	-172.21 (1.413)	38.226 (5.75)[a]	.0465 (1.66)[c]	3.8766 (1.169)	-5.3489 (3.113)[a]	-.9561 (1.014)
Pulses						
Linear	-13.756 (.396)	.8834 (.262)	.0026 (.42)	.0589 (.29)	-2.706 (2.16)[b]	1.2534 (2.57)[b]
Nonlinear	-25.963 (.69[illegible])	-.25 (.075)	-.0102 (.721)	1.1789 (2.436)[b]	-2.3281 (1.893)[c]	1.4295 (2.94[illegible])[a]

TABLE 6

TABLE OF COEFFICIENTS OF THE MULTIVARIATE REGRESSION MODEL FOR CONSUMPTION FUNCTIONS OF VARIOUS CROPS (POOLED DATA)

(Linear and Nonlinear Hypotheses)

Crop/ Equation	Constant	A(t)	Y(t)	Q(t)	P(t)	S(t)	$P_s(t)$	$Q^2(t)$	$Y^2(t)$
					Independent Variables				
Wheat									
Linear Equation	-231.1 (.755)	147.6 (7.47)	.05938 (1.646)	-.4325 (.1385)	17.86 (1.454)	-7.451 (2.033)	-13.77 (1.01)		
Nonlinear Equation	-197.4 (.5316)	143.4 (7.069)	.1207 (1.129)	-.0421 (.6816)	17.77 (1.416)	[illegible] ([illegible])	-15.26 (1.106)	.04246 (.7626)	-.0000082 (.6223)
Maize									
Linear Equation	-261.9 (1.925)	62.33 (6.65)	-.0126 (.8379)	9.86 (5.406)	11.25 (1.773)	-2.936 (2.061)	-3.679 (.6406)		
Nonlinear Equation	-229.5 (1.704)	67.4 (7.25)	-.091 (2.435)	9.393 (2.838)	12.8 (2.071)	-3.202 (2.293)	-3.679 (.6585)	-.01103 (.2543)	.00001 (2.246)
Rice									
Linear Equation	-60.62 (1.347)	3.122 (1.649)	-.000596 (.1736)	.7429 (2.683)	1.054 (.8983	-.5189 (1.382)	1.222 (1.047)		
Nonlinear Equation	-78.81 (1.869)	2.554 (1.433)	.01366 (1.605)	3.578 (3.847)	1.451 (1.34)	-.4253 (.9873)	.6151 (.5569)	-.03205 (3.099)	-.0000017 (1.748)

TABLE 6 (cont'd.)

Crop/ Equation	Independent Variables								
	Constant	A(t)	$\acute{Y}(t)$	Q(t)	P(t)	S(t)	$P_s(t)$	$Q^2(t)$	$Y^2(t)$
Sugarcane									
Linear Equation	-40.58 (.4409)	39.62 (6.842)	.01366 (1.269)	.4037 (.4534)	-5.626 (.359)	-.7872 (.9254)	7.732 (3.24)		
Nonlinear Equation	-162.5 (1.441)	37.53 (5.996)	.04112 (1.563)	3.716 (1.211)	-5.485 (3.429)	-8.142 (.9221)	9.16[illegible] (3.[illegible])	-.03939 (.0469)	-.0000033 (1.046)
Pulses									
Linear Equation	-19.0 (.6015)	1.158 (.3652)	.001686 (.213)	.1407 (.8118)	-1.669 (1.527)	1.209 (2.658)	3.313 (3.075)		
Nonlinear Equation	-26.13 (.7674)	-.0568 (.0183)	.01125 (.8643)	1.009 (2.394)	-1.506 (1.390)	1.463 (3.241)	2.791 (2.586)	-.00366 (2.177)	-.0000013 (.5562)

Note: The figures in the parentheses is the value of the 't' statistic.

4. THE EMPIRICAL RESULTS

The results will be discussed crop by crop, first for the model that does not account for the inter-crop error variances and is represented by the system of equations in (14), followed by the results for the multivariate regression model represented by the system of equations in (16).

4.1 Separate Crop Models

Table 6 gives the results for the five crops for the model that assumes that no inter-crop error variances exist in the consumption functions of the peasant households. The results show two sets of equations - the first one is linear in all the independent variables, while the second is non-linear in incomes and outputs.

a) Wheat

On examining the equations fitted to the transformed pooled data for wheat the following observations are relevant:

i) The R^2 is relatively small for both equations. Considering the fact that pooled data includes considerable variations between households (borne out by our earlier discussions about aggregation bias) as well as some variations over time, we should not expect the R^2 for any of the crop equations to be very high.

ii) Only the coefficients associated with the family size and the output of the nearest substitute (maize) are significant in both the equations and both have the expected signs. This fact suggests that the consumption of the staple food crop in the Punjab depends upon the size of the family most significantly and then upon the total output of the amount of maize the family produces. The dependence of consumption upon the output of the substitute crop rather than upon the output of the subsistence crop itself can be explained by the fact that when wheat is planted farmers already have retained behind amounts of maize from the summer season. (This is also true for the case of maize where farmers know the amount of wheat retained from last winters crop, but less so). More significantly the results suggest that real factors play an important role.

iii) The sign of the coefficient of output has a positive sign which changes to a negative sign when the Q^2 term is introduced. The implication of this is that in the range of the data availa le consumption and output are linearly related. This is also borne out by the insignificance of the coefficient of the Q^2 term in eq. 2. If this is correct then this has important policy implications, for it suggest that the mpc out of output is constant (at least over the range of the data used) and that we cannot expect the mpc to be greater than the apc as outputs increase in the process of development. This fact has two important implications for policy: first we cannot expect to increase the marketable surplus as a percentage of output, as output increases (unless other factors such as income and family size cause reductions in consumption) over time, and secondly taking a cross-section view we cannot expect marketable surplus to increase with an increase in the size of the farm, if we expect larger outputs to be associated with larger farms. Thus given the range of the size of the farms in our data (3 to 23 acres in the 1964-65 sample) we cannot expect larger farms to generate a larger percentage of marketable surplus, thus negating one of the arguments for a large farm size. This of course does not preclude the possibility of this percentage increasing if the size of the farm (and hence total output per household) increases substantially above the current average size of farms in the Punjab, but it does imply that farm size will have to be increased substantially above say 25 acres before the mpc to consume out of output falls below the apc. This conclusion was also borne out by RAJ KRISHNA (1965) even though he used only cross section data for one year.

These conclusions however have to be seriously modified in view of the fact that aggregation bias exists. The test for aggregation bias included other variables besides output and income and does not specifically lead us to believe that the parameters associating subsistence consumption to these variables vary from household to household, but this is quite possible. Therefore we have to modify our conclusions with regard to the possibility of the mpc being constant over the relevant range of outputs, and to this extent we cannot draw the above policy implications in those strong terms.

This has a major bearing on a policy question of prime importance in India today - should one concentrate upon increasing the productivity of the larger farmers, in the hope that they will generate a larger percentage of marketable surplus, even when this militates against equity considerations, or does one spread out ones development programs and concentrate upon making small farms which are actually more productive through their use of intensive inputs.

iv) Total farm income has a very small effect on the level of consumption of wheat and though eq. 2 suggests a decrease in consumption as income increases this effect is too small to have any significance, so that we can say that to the extent that income is important, it is linearly related to consumption of wheat. The above implications of aggregation bias also hold in the case of income.

v) The coefficients of the price variables suggest that their effect though insignificant statistically is very large, but the signs are the opposite of what one would conventionally expect. Thus consumption increases with the increase in the price of the crop and decreases with an increase in the price of the substitute crop. The possibility of this was already anticipated in the case of a crop whose output is a significant part of the farmers cultivating income. This is certainly the case with wheat which is the main crop and with maize which is the most important summer crop. In general one can say that the greater the extent of subsistence in a crop, the more likely that price effects show up as income effects, and the more likely that the elasticity of supply with respect to price will be small. This is indeed the case when supply studies have not accounted for the nature of interdependence and have tried to relate marketable surplus to price, and have found it very low. This is bound to be the case if consumption increases with an increase in price and a result decrease in the marketable surplus. The implications of these facts is not that peasant farmers are irrational and do not respond to economic considerations, but it is evidence that perhaps they are far more rational than they seem for they take full account of the affect of prices on their real incomes before they make their decisions with respect to prices. Again the policy implications are important, for a low elasticity of the marketable surplus to prices is accompanied by a high elasticity of consumption to prices and as prices increase farmers may actually increase their consumption of their outputs for those crops that are highly subsistence and whose outputs contribute a large part of their real incomes.

The results for wheat have been discussed in detail along with their policy implications because in the Punjab wheat is the most important crop in the diet, in the cropping pattern and in terms of the marketable surplus. The same implications, though not discussed in detail will be relevant for the other crops, though to a lesser degree.

b) Maize

Maize is the second most important crop in the diet and is the major summer crop. (The results indicate the following points of interest:

i) Family size and the output of maize are both significant and large determinants of subsistence consumption of maize, in both the equations. In addition the output of wheat is also significant as a determinant, suggesting that the larger the output of wheat the less the amount of maize retained for domestic consumption. This is because wheat and maize are very good subsitutes for each other in the diet.

ii) The size and the significance of the non-linear terms in output and income suggest that subsistence consumption is linearly related to these variables with the consequent implications above.

iii) The price of maize is both a significant and large determinant of subsistence consumption, though the price of the substitute crop wheat is not important.

iv) Income is significant in the linear and not significant in the non-linear equation, but in both it has a negative sign suggesting that maize is an "inferior" good, its consumption declining with increases in income. This is due to the fact that maize is inferior to wheat for which it is a good substitute in the diet of the farmers.

c) Rice

In terms of both the value of rice in the total food budget as well as the amount of rice consumed, it is the least important food crop in the diet. The Punjab is not a rice eater and consumes small amounts only at festive occasions. It is mainly grown as a cash crop and even though its level of subsistence is high (70%), all this means is that of the rice that is consumed, a large share is obtained from production. In terms of its importance in the consumption of a peasant household it can be considered more of a "cash crop", grown for sale rather than as a subsistence crop grown for home consumption. The results reflect the relative importance of monetary factors strengthening this interpretation:

i) Even though the coefficient of family size is significant it is not large compared to coefficients for the other crops.

ii) The coefficients with respect to output are significant even though they are small and in the case of rice the coefficient of Q^2 is significant and large suggesting that at relatively small levels of output the mpc begins to decline and marketable surplus as a percentage of total output to increase.

iii) The price coefficients are small and insignificant suggesting that the consumption of rice does not depend upon price, nor upon the real income effects of price since it represents only a small part of farm output and even a smaller part of household consumption.

d) <u>Sugarcane</u>

Sugarcane is another cash crop though less so than rice, and consequently the same arguments are valid in its case. In addition the extent of subsistence for sugarcane is the smallest for reasons already pointed out earlier in the paper. Thus sugarcane would reflect the importance of monetary factors more than the other crops. The results show

i) The importance of the size of family is still paramount as in the case of all the crops, its coefficient being both significant and large.

ii) The next most important factor is the price of sugarcane and the price of the substitute crop wheat (wheat is used as a substitute crop because it competes with sugarcane for all production inputs-being an annual crop it occupies the land during winter on which wheat could be planted). In the case of sugarcane the signs of the price coefficients are not perverse, in that they show consumption declining with an increase in the price of sugar and increasing with an increase in the price of the substitute. This is exactly what one would expect of a crop that is more cash than subsistence, bearing out the fact that as the relative importance of subsistence declines the relative importance of monetary factors increases.

iii) Consumption is not related in a non-linear way to income and output and income is not significant at all.

e) Pulses

The results for pulses are a bit difficult to interpret since data was available on the consumption of all pulses but only on the production of gram which constitutes only some 49% of all pulses consumed. So the relationship between the consumption of pulses and their output which one would have expected does not show up, even though gram accounts for some 75% of all pulses produced. However the results show:

i) Family size and incomes are not significant, and neither is output except in the non-linear case. The latter suggests that consumption is related to output in a non-linear manner, and is the only case along with rice where this relationship is borne out. The mpc declines with increases in output and the reason for this is perhaps that pulses are even further down the line of preference as a foodgrain after wheat and rice and increased outputs are not consumed but marketed if the alternative outputs are available.

ii) The price of wheat and its output are both significant in explaining the consumption of pulses, which declines with an increase in the price of wheat and increases with an increase in its output. The first is easily explained by the fact that a substantial increase in the price of wheat represents a large increase in real income to the household and its substitutes wheat or maize for the inferior pulses in its diet and this is as expected. It is not so easy to explain the latter effect which suggest a certain amount of complementarity in the consumption pattern between wheat and gram which in fact is not observed.

4.2 The Multivariate Regression Model

Table 6 gives the result of the multivariate regression model which was used in the last stages of the estimation mainly to allow us to improve our estimates by dropping the unrealistic assumption of the lack of inter-crop variances in the consumption functions. There is no need for a detailed crop by crop discussion of the results because by and large they remain the same and the same comments will be borne out. The main advantage of the use of this step is that it allows an improved estimation by reducing the standard error of the estimates and making them unbiased. A comparison of the two sets of results it is evident that this has happened though the improvement in both the standard error of the estimates and a change in the size of the coefficients is not at all significant. However these estimates rather than one in table 5 were actually used in predicting values for the annual household consumption of the subsistence crops.

The predicted and observed values for household consumption for the five crops for 1952-53 to 1964-65 in the Punjab are given in table 7 for the purpose of seeing how useful the multivariate regression model was for the purpose of prediction. This aspect of the problem however belongs in the larger model of supply response and is not directly relevant here.

TABLE 7 . OBSERVED AND PREDICTED ANNUAL HOUSEHOLD CONSUMPTION OF SUBSISTENCE CROPS IN THE PUNJAB: 1952-53 to 1964-65 (In Kgs.)

YEAR	WHEAT		MAIZE		RICE		SUGARCANE*		PULSES	
	OBS.	PRED.	OBS.	PRED.	OBS.	PRED	OBS.	PRED.	OBS.	PRED.
1952-53	(a)	889.2	(a)	350.9	(a)	22.3	(a)	304.4	(a)	76.6
1953-54	932.0	859.6	403.7	331.9	29.1	18.1	251.6	208.8	120.7	95.6
1954-55	984.0	905.4	385.8	363.5	56.9	23.1	254.7	259.4	127.8	113.9
1955-56	839.0	(b)	466.0	(b)	48.6	(b)	263.3	(b)	132.1	(b)
1956-57	872.0	865.3	442.7	350.9	52.0	18.9	327.7	272.8	133.2	100.0
1957-58	974.0	894.3	283.4	349.6	9.8	25.7	324.6	294.5	93.2	86.4
1958-59	919.0	860.6	282.6	313.7	54.7	18.6	246.2	259.5	147.5	79.3
1959-60	923.0	971.7	280.1	236.7	17.7	13.9	245.6	248.6	103.7	90.5
1960-61	917.0	910.5	288.2	286.8	15.0	20.9	317.6	249.4	94.3	92.4
1961-62	1167.0	963.5	306.5	330.8	53.7	23.1	254.5	289.9	53.9	94.6
1962-63	1086.0	981.9	437.5	273.0	24.8	20.6	198.8	235.8	61.9	95.6
1963-64	962.0	827.4	430.3	319.8	24.1	8.8	200.3	111.1	72.2	73.7
1964-65	1025.0	765.0	496.1	361.5	27.9	13.1	211.0	178.9	65.3	101.1

* Consumption of brown sugar.

a) Data on consumption not available. b) Data on production not available.

Source for observed values: Board of Economic Inquiry (Punjab): Farm Accounts in the Punjab, 1952-53 to 1964-65, Economic and Statistical Organisation, Government, Punjab, Chandigarh.

5. SOME TENTATIVE CONCLUSIONS

In view of the discussion of the results presented in the last section it is possible to venture some tentative conclusions:

i) Real factors such as family size and total physical outputs are the most important determinants of subsistence consumption. The relative importance of these factors declines as the level of subsistence decreases and as crops become increasingly a part of the monetized nexus, while the relative importance of monetary factors increases.

ii) The linear relationship between subsistence consumption and output suggests a) that total output per farm would have to increase considerably over the current levels to increase the percentages of the marketable surplus forthcoming out of production, even though output is increasing and b) by implication the average farm size would have to increase considerably over the current level to increase the ratio of the marketable surplus to output in the Punjab. Both these suggest that higher outputs or increases in the farm size are not likely to reduce the marginal propensity to consume out of output and increase the marginal surplus as a percentage of total output significantly. This conclusion must be modified in view of the implications of the aggregation bias that was found in the data. Further research however is necessary before such a conclusion can be categorically supported.

iii) Prices play a significant role if we measure their impact upon subsistence consumption (even though in some cases their coefficients are statistically insignificant), but their effect is not easy to predict. If the extent of subsistence is high, an increase in the price of an output may increase its consumption, while as the relative importance of subsistence declines it may reduce consumption. Though it is not possible to generalize a-priori, without actual empirical estimation, however we can say that as the relative importance of subsistence declines we may expect an increase in the price of the output to decrease consumption and an increase in the price of the substitute output to increase it.

iv) Income plays no part in the consumption of subsistence crops once account has been taken of the real factors such as family size, outputs and prices. (Indeed even when income is the only factors used it still has no significant correlation with the consumption of any of the above crops).

v) It is not possible to infer the importance of market prices by only an examination of the response of marketable surplus to them. A perverse relationship between the two is likely to exist in the case of crops with a high degree of subsistence, and this relationship is not enough to allow us to infer the possibility of increasing argicultural output and productivity through the use of market incentives.

vi) What is required in a study of supply response in peasant agriculture is a proper understanding of the importance of subsistence consumption and its impact upon production decisions in the contect of the existing firm-household interdependence.

References

Behrman, J. R., "Price Elasticity of the Marketable Surplus of a Subsistence Crop", Journal of Farm Economics, November, 1966.

Board of Economic Inquiry, Punjab, India: Family Budgets of ... Cultivators in the Punjab, 1954-55, ..., 1964-65; The Economic and Statistical Organization, Punjab Government; Publication Nos. 44, 52, 57, 59, 73, 82, 85, 94, 101, 105 and 114.

Board of Economic Inquiry (Punjab) Farm Accounts in the Punjab 1950-51, ... 1964-65, The Economic and Statistical Organization, Government Punjab.

Board of Economic Inquiry (Punjab), Index of Parity Between Prices Received and Paid by Farmers, 1950-51, ..., 1962-63, Economic and Statistical Organization, Government, Punjab.

Clark, C. and Haswell, M. R. (1964), The Economics of Subsistence Agriculture, St. Martins Press, New York, 1964.

Cochrane, D. and Orcutt G. H., (1949), "Application of Least Squares Regressions to Relationships Containing Autocorrelated Error Terms", Journal of the American Statistical Association, Vol. 44, pp. 32-61, 1949.

Day, R. H. (1962), "An Approach to Production Response", Agricultural Economic Research, Economic Research Service, Vo. XIV, No. 4, October, 1962.

Day, R. H. and T. Heidhues (1967), "Towards a Microeconomic Model of Agricultural Production and Development", Systems Formulation, Methodology and Policy Workshop, Paper No. 6702, Social Systems Research Institute, University of Wisconsin, 1967.

Directorate of National Sample Surveys, India (1958-1959), Tables With Notes on Consumer Expenditures, 13th Round, Sept.-May 1958, publication No. 80 and 14th Round July 1958-June 1959, publication No. 102.

Economic and Statistical Organization (Punjab), Statistical Abstract of the Punjab, 1964, Economic and Statistical Organization, Punjab Government, Chandigarhs, India.

Food and Agricultural Organization, United Nations (1950 and 1957); Calorie Requirements F.A.O. Nutritional Studies No. 5, June 1950 and No. 15, 1957.

Goldberger, A. S. (1963), Econometric Theory, John Wiley and Sons, New York, 1963.

Hanumantha Rao, C. H. (1965), "The Marketable Surplus Function for a Subsistence Crop-Comments", Economic Weekly, April 17, 1965.

Heady, E. D., W. B. Back and E. A. Peterson (1953), "Interdependence Between the Farm Business and the Farm Household with Implications for Economic Efficiency", Research Bulletin No. 398, Agricultural Experimental Station, Iowa State College, Ames, Iowa.

Indian Council of Medical Research, Report of Nutrition Work Drive in the States, 1950, ..., 1961, Nutrition Research Laboratories, Indian Council of Medical Research, New Delli.

Johnston, J. (1960), Econometric Methods, McGraw Hill, New York, 1960.

Krishna, Raj (1965), "The Marketable Surplus Function for a Subsistence Crop - An Analysis with Indian Data", Economic Weekly, Annual Number, February, 1965.

Krishnaji, N. (1965), "The Marketable Surplus Function of a Subsistence Crop - Comments", Economic Weekly, April 17, 1965.

Kuh, Edwin (1959), "The Validity of Cross-Sectionally Estimated Behaviour Equations in Time Series Applications", Econometrica, Vol. 27, April 1959, pp. 197-214.

Kuh, Edwin and Meyer, John (1959), "How Extraneous are Extraneous Estimates?", Review of Economics and Statistics, November 1957, pp. 390-393.

Majumdar, M., "The Marketable Surplus Function of a Subsistence Crop - Further Comments", Economic Weekly, May 15, 1965.

Mellor, John W. (1965), "The Subsistence Farmer in Traditional Economies," paper presented at the A.D.C. Seminar on Subsistence and Peasant Economies East-West Center, Honolulu, Hawaii, February-March, 1965.

Mellor, John W. (1965), "Towards a Theory of Agricultural Development", paper prepared for the S.S.R.C. Symposium on Agriculture and Development, University of Chicago, May, 1965.

Nakajima, Chihiro (1957), "Equilibrium Theory of the Family Farm," Osaka Daigaku Keisaigaku, July, 1967.

Nakajima, Chihiro (1958), "On the Graphical Representation of Subjective Equilibrium on a Family Farm", Osaka Daigaku Keisaigaku, January, 1958.

Nakajima, Chihiro (1963), "Subjective Equilibrium of the Family Farm", in Economic Development and Agriculture in Japan, edited by K. Okhawa, 1963.

Nakajima, Chihiro (1965), "The Subsistence Farmer in Commercial Economies", paper presented at the A.D.C. Seminar on Subsistence and Peasant Economies, East-West Center, Honolulu, Hawaii, February-March, 1965.

Prasad, Brahmanand, "Marketable Surplus Function of a Subsistence Crop - Further Comments", Economic Weekly, May 15, 1965.

Singh, I. J. (1968), "Recursive Programming Models of Agriculture Development" Econometrics and Mathematical Economics Workshop, paper No. 6836, Social Systems Research Institute, University of Wisconsin, 1968.

Singh, I. J., Richard H. Day and S. S. Johl (1968), Field Crop Technology in Punjab, India, Social Systems Research Institute, University of Wisconsin, 1968.

Theil, H. (1954), Linear Aggregation of Economic Relations, North Holland Publishing Co., Amsterdam, 1954.

Wharton, Clifton Jr., (1958), "The Economic Meaning of Subsistence", The Malayan Economic Review, Vol. VIII, No. 2, October, 1958, pp. 46-58.

Zellner, A. (1962), "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", Journal of the American Statistical Association, June, 1962.